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J.J. Millspaugh
J.H. Schulz
T.W. Mong
D. Burhans
W.D. Walter
R. Bredesen
R.D. Pritchert, Jr.
D.C. Dey
Univ. of Missouri, Columbia, MO

# Agroforestry Wildlife Benefits

Agroforestry provides an opportunity to link timber production with other benefits, including improved wildlife habitat. Many modern agricultural practices, such as monocultural production (Soule et al., 1990), the use of pesticides and herbicides, and increases in field size, have proven detrimental to many wildlife species (Warner and Etter, 1985). Because of the increasing public sentiment favoring diverse ecosystems that are economically viable, agroforestry may be an option for some private landowners interested in linking commodity production with wildlife benefits (Husak, 2001). Many landowners view the presence of wildlife as an important byproduct to the production of wood products on their land, especially in the southeastern United States (Allen et al., 1996). In addition to wildlife benefits, agroforestry offers diverse environmental, aesthetic, and recreational opportunities over many other modern agricultural practices through diversity in plantings, both structurally and spatially (Kelly et al., 1990; Warwick, 2003).

The types of wildlife species that benefit from agroforestry practices vary with region and ecotype and depend on the landscape context, size of the agroforestry area, and the types, spatial configuration, and age of plantings. For example, wildlife species that are sensitive to habitat fragmentation, such as spotted owls (*Strix occidentalis* Xantus de Vesey) or pileated woodpecker (*Dryocopus pileatus* L.), will not benefit in the same capacity as those adapted to fragmented habitats, like blue jay (*Cyanocitta cristata* L.) or white-tailed deer (*Odocoileus virginianus* Zimmermann). The wildlife benefits derived from agroforestry practices are driven by the goals and investment of the landowner and constrained by the habitat and landscape features of the proposed project. To maximize the feasibility of meeting those goals, traditional agroforestry plantings can be slightly modified and selected to meet the needs of wildlife species with little impact on the production of wood products or field management. By altering traditional agroforestry plantings and selecting tree and shrub species carefully, landowners can also develop a new wildlife product and diversify their returns. The wildlife production gained from the conversion to an agroforestry practice can allow landowners to better balance the compromise among the competing interests of agriculture, wildlife, and potential wood products. That balance can be achieved through possibilities such as earning potential through lease hunting opportunities and aesthetic benefits perceived by the landowner.

There is an inherent compromise when balancing the production of wood products, crop income, and wildlife abundance in agroforestry practices. It is often easier for landowners to see the direct benefit of a traditional agriculture practice through a practical

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cost-vs.-income comparison, compared with an agroforestry practice where the aesthetic, ecosystem health, and alternative income benefits may be important considerations. For example, when converting traditional agricultural land into agroforestry plantations, there may be a temporary loss of productive land, with associated losses of income. However, these short-term losses can be offset by considering the short- and long-term earning potential of wildlife hunt leases and long-term investment of wood products. If the landowner resides in a region where lease hunting is popular or where a highly desirable huntable species is common, the short-term loss of agricultural income can be at least partially reclaimed. If a goal of the conversion to agroforestry is to create an alternative revenue stream through hunt leases, landowners must create a plan that accounts for not only increasing the population of the main species or group of species (e.g., male deer with large antlers) of interest but considering how wildlife diversity and abundance changes through time.

This chapter is focused on wildlife benefits in agroforestry settings. We view wildlife production as a valuable byproduct that can be complementary to the goals of tree and crop production. Wildlife is also an important consideration for landowners because it may diversify income opportunities, particularly early in the initiation of agroforestry practices, with only modest alterations to plantings and management techniques. We describe the benefits to wildlife in a variety of agroforestry settings and discuss the general ecological issues, such as scale and habitat fragmentation, that should be considered when attempting to maximize wildlife benefits. Next, we describe the integration of agroforestry with lease hunting, with an emphasis on mourning dove (*Zenaida macroura* L.) harvests as an example. We conclude with some general recommendations to improve wildlife benefits in agroforestry settings.

## Wildlife Considerations in Agroforestry Settings

There are several important ecological concepts central to the consideration of wildlife benefits in agroforestry settings. In this section we provide an overview of these issues to provide context for our recommendations and conclusions about improving wildlife benefits in agroforestry settings.

### Scale, Patch Size, and Fragmentation

Effectiveness of management for wildlife populations will depend in part on considerations of scale (Donovan et al., 2002). Often the scale of agroforestry practices is small enough (e.g., 4–8 ha) that benefits to many wildlife species are not attainable or practical. For some forest and grassland songbirds, even large habitat patches will have lower benefits if not part of a larger forested or grassland landscape (Fitzgerald and Pashley, 2000; Fitzgerald et al., 2000). Birds may not be present in small patches, or if present, may not exhibit a positive population growth rate due to lowered reproductive success from cowbird parasitism and nest predation that is often experienced in landscapes that are fragmented (Robinson et al., 1995). Mammalian populations may experience similar fates if habitats are isolated. For example, in west-central Indiana, species richness of small mammals was highest in continuous forest sites and increased with area (Nupp and Swihart, 2000). Furthermore, one needs to consider the normal density of wildlife within the context of the size of the agroforestry area. For example, if our goal for northern bobwhite quail (*Colinus virginianus* L.) density was 1 per 0.8 ha, this density implies that one covey of quail might be produced per 8.1 ha, which might be acceptable to some landowners. Given a 44% harvest rate, including crippling (Roseberry and Klimstra, 1984), the additional covey would only result in about three additional quail in the bag during an average hunting season. Within the context of quail population and habitat management, size and location of habitat management efforts are serious considerations if increased hunting opportunity is one of the desired outcomes (Schulz et al., 2003).

Benefits to wildlife at the level of the agroforestry plot may be negated by factors operating at larger scales. Elliot and Root (2006) believed that the linear and fragmented makeup of their riparian forest sites in northeastern Missouri resulted in a small mammal species assemblage dominated by habitat generalists. Also in northeastern Missouri, Peak et al. (2004) concluded that buffer strips did not provide better songbird breeding opportunities because of the overriding influence of agricultural landscapes on increased nest predation. Similarly, Davros et al. (2006) reported that landscape context was a critical determinant of butterfly use of filter strips in southwestern Minnesota. Such studies demonstrate the importance of landscape context; the wildlife benefit that may be derived from agroforestry is directly related to the surrounding habitat matrix.

Woodlots within a traditional agricultural setting have fewer wildlife benefits. For example, in agroecosystems dominated by intensive monoculture row-crop farming, such as corn (*Zea mays* L.) or soybean [*Glycine max* (L.) Merr.], wildlife benefits will likely be reduced (Tewksbury et al., 2006). In particular, there is an increase in nest predation in areas within an agricultural matrix (Tewksbury et al., 2006) when compared with other environments. Using a meta-analysis, Chalfoun et al. (2002) found that small-scale edge and patch effects were most common in forests where agriculture was the dominant land use. Higher predation rates might relate to increased predator densities in these areas because additional food is available in agricultural settings (Marzluff et al., 1998; Dijak and Thompson, 2000). Thus, landscape context is important in determining the overall benefits that may be derived from agroforestry practices.

Where possible, the use of larger or more connected restoration fragments is more desirable than the creation of small, unconnected fragments. Twedt and Cooper (2005) indicated that edge effects on nest survival for some forest birds were less severe where reforestation was widespread in the landscape. Because cowbird parasitism typically decreases with distance from forest edges, they recommended reforestation for forest birds near large preexisting forest tracts rather than near small preexisting patches (Twedt and Cooper, 2005). In a survey of the Mississippi Alluvial Valley, researchers found that most remaining forest patches were small (<1012 ha; Twedt and Loesch, 1999). They suggested that, at least for forest songbird species, reforestation efforts should be concentrated on large tracts, either by adding or linking to existing forested patches of land. In Louisiana, a Louisiana black bear (*Ursus americanus* Pallas) project area has been established to reconnect fragmented blocks of hardwood forest to facilitate dispersal amongst populations (King et al., 2006). For amphibians, fragmentation of natural habitats limits dispersal while decreasing opportunities for wetland colonization (Semlitsch, 2000). These studies collectively underscore the importance of habitat connectivity within a larger spatial framework. Agroforestry offers an opportunity to minimize the negative consequences of fragmentation by reducing habitat isolation (Allen et al., 1996) provided plantings are well planned and well connected with other habitats.

Minimizing habitat isolation also helps prevent predator traps, which result when prey species are attracted to isolated patches of habitat, which in turn increases predator use of those sites (Fretwell and Shipley, 1981), and increased amount of edge, which makes prey more vulnerable (Wilcove, 1985). Agroforestry plantations can result in predator traps because sometimes these areas are isolated and maintain high edge/interior ratios, which favor predation (Tewksbury et al., 2006). Such areas are sometimes attractive to prey species, such as migrating birds. For example, Kelly et al. (1990) described agroforestry sites in the San Joaquin Valley in California as "biological magnets" for birds. More research is needed to better understand whether agroforestry sites that attract wildlife are actually predator traps.

## Source and Sink Populations

Wildlife populations residing in agricultural landscapes often exhibit source–sink population dynamics. In such cases, sinks (e.g., small marginal patches of habitat) are supported and sustained by immigration from sources (e.g., larger, high-quality patches of habitat; Pulliam, 1988). In this context, agroforestry fields might be habitat sinks for many wildlife species. The characteristics of agroforestry sites, such as the presence of vegetation edges, might contribute to the presence of predators. Increasing numbers of predators along with increased nest predation (Hoover et al., 2006) and cowbird parasitism can negate reproductive success of animals within agroforestry environments. Thus, wildlife abundance in agroforestry settings might be determined more by the availability of surrounding sources than production of wildlife from within the area.

Although more research is needed to address the hypothesis that agroforestry settings may act as population sinks, work by the authors (J.J. Millspaugh and D.C. Dey, unpublished data, 2004) with cottontail rabbits (*Sylvilagus floridanus* J.A. Allen) supports the hypothesis. Over the 3-yr period from 2001 to 2004, we used a combination of mark–recapture and telemetry studies to assess cottontail rabbit demographics (e.g., density, survival rates) and movements within 4- to 16.2-ha agroforestry fields. The bottomland sites were located in central Missouri and planted with swamp white oak (*Quercus bicolor* Willd.) and pin oak (*Quercus palustris* Muenchh.) seedlings as 1–0 bare-root, 11.4-L (12-quart) RPM (Root Production Method, RPM Ecosystems, Dryden, NY), or 18.9-L (20-quart) RPM (Shaw et al., 2003; Grossman et al., 2003). When compared with control sites, we observed similar rabbit densities, but we noted that rabbit survival rates in agroforestry plots were only one-third those of rabbits in control plots (Millspaugh, unpublished data, 2004). Predation was the major source of mortality of rabbits in agroforestry plots. Using Leslie matrix models (Caswell, 2001), population growth rates were negative in agroforestry plots and positive in control plots. Our telemetry work demonstrated that rabbits from surrounding sites dispersed to agroforestry plots; once in agroforestry plots there was no indication of further movement beyond the sites.

## Landowner Goal Setting

When landowners are interested in increasing wildlife on their property, success improves if landowners clearly identify their goals (e.g., increased hunting for family and friends, additional income, and/or viewing new wildlife species). It is also necessary to identify short- and long-term wildlife objectives. By addressing these questions, it becomes possible to identify appropriate management strategies and select appropriate tree and shrub plantings. It also becomes possible to arrange plantings to maximize benefits to wildlife of interest. Without explicit planning, a landowner may later be disappointed by a lack of return on their investment.

It is important to remember that not all wildlife benefits from agroforestry practices. Landowners are more likely to achieve success if habitat development and management activities focus on meeting the needs associated with a specific group of wildlife. Landowners should consider the intended use of wildlife, such as viewing versus hunter harvest, when planning agroforestry practices. For example, landowners should recognize that as forests mature (i.e., succession), the wildlife species that occupy these forests will change. Early in the development of agroforestry habitats (0–15 yr), we can expect that early successional species (e.g., quail, rabbits, field sparrow [*Spizella pusilla* A. Wilson]) will benefit most (Fig. 10–1). As the plantings mature (15–30 yr), there will be a transitional period and the ground cover starts to diminish. During this time, species such as northern cardinals (*Cardinalis cardinalis* L.) and brown thrashers (*Toxostoma rufum* L.) will benefit most. Finally, as trees mature (30–60 yr), we can expect late successional species such as wild turkeys (*Meleagris gallopavo* L.) and gray squirrels (*Sciurus carolinensis* Gmelin) to benefit most, due to the production of mast, for example. Recognition that wildlife benefits and opportunities will change as plantings mature allows landowners to set and attain realistic goals and avoid later disappointment.

In addition to the issues discussed above about landscape context, other physical characteristics, such as field size, should be considered when setting goals for any agroforestry practice. Such factors inherently limit what can be accomplished and what can be expected at the site. For example, our previous discussion of scale issues and quail indicated that we might expect 0.8 quail $ha^{-1}$ in an optimally managed site. In the case of an 8-ha agroforestry site, this might mean an additional covey of quail. Although this benefit might be attractive to a landowner, there would be few corresponding economic benefits. In contrast, our data in western Missouri demonstrates that agroforestry fields planted with sunflower (*Helianthus annuus* L.) as a cover crop can result in the harvest of roughly 50 mourning doves $ha^{-1}$ (Rick Bredesen, Missouri Dep. of Conservation, unpublished data, 2006). Therefore, if there is interest in economic returns through lease hunting opportunities, mourning doves might be a more appropriate option. However, this prioritization depends on the objectives of the landowner and the value placed on different wildlife species.

Our point is that landowners have multiple options for investing in wildlife benefits, and decisions should be directly tied to their objectives. Such objectives should be clearly stated at the outset because they will determine decisions about types of trees, distance between plantings, cover crops, and even field configuration. Some options might prove economically viable (e.g., mourning dove lease program), whereas others might offer more aesthetic opportunities (e.g., wildlife viewing in general). It is important

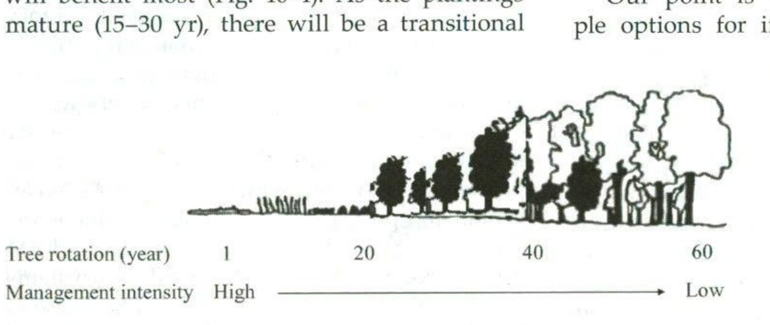


**Fig. 10–1. Relationships among available species for lease hunting showing how tree growth through an agroforestry tree rotation changes the corresponding wildlife habitat and resulting lease hunting options.**

for landowners to recognize that agroforestry plantings are not static environments; setting of objectives must take into account changes in vegetative structure of the area as trees mature. For example, a mourning dove lease program might not be viable once trees mature and the area that may be planted to sunflowers is diminished. As with any investment, both short and long-term goals must be considered, along with changing expectations through time. Lastly, landowners should consider undesirable consequences of attracting wildlife, including damage concerns.

## Wildlife Damage

Despite the positive wildlife benefits that we discuss throughout this chapter, wildlife may cause considerable damage in agroforestry fields. Eastern cottontail rabbits and white-tailed deer routinely forage on tree and crop plantings (Fig. 10–2). Deer also rub their antlers on trees during the fall mating season, causing additional damage that may kill trees (Fig. 10–2). Damage caused by rabbits most often occurs in the winter, when rabbits routinely feed on the buds, bark, shoots, and twigs of vines, shrubs, and trees, especially when the ground is snow covered (Haugen, 1942; Schwartz and Schwartz, 1995). During the summer, rabbit damage to woody plants is minimal because of the abundance of preferred grasses, legumes, and forbs, but in winter rabbits can cause severe damage to tree reproduction by pruning, barking, and girdling stems and shoots, which

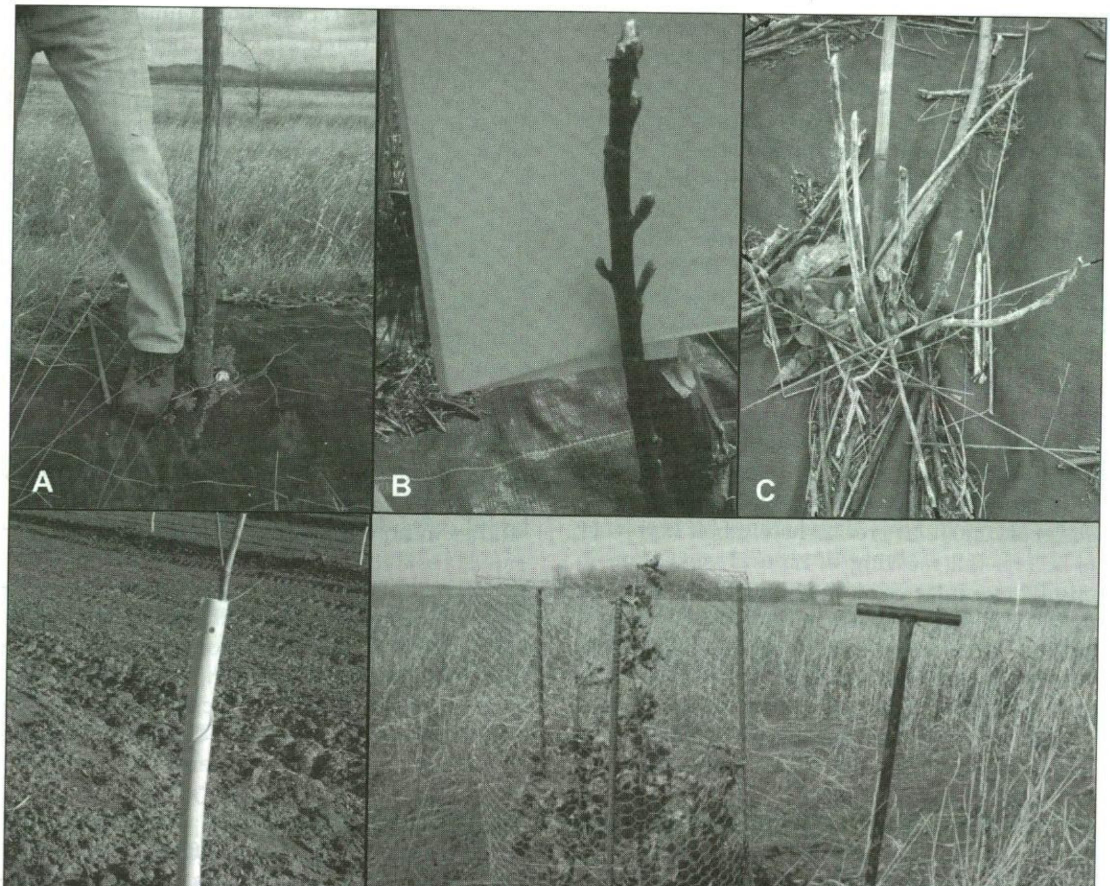


**Fig. 10–2. (A) Damage from deer rubbing antlers on tree. (B) Evidence of deer browsing on tree. (C) Damage from rabbit herbivory. (D) Tree guard to protect against rabbit herbivory. (E) Chicken wire used to protect tree from wildlife damage. All photos taken within agroforestry stands from Plowboy Bend Conservation Area, Missouri (Shaw et al., 2003).**

often increases seedling mortality (Geis, 1954; Meiners and Martinkovic, 2001). Rabbits leave a distinctive 45° angle cut on woody vegetation compared with deer (Fig. 10–2). Deer do not have upper incisors, which results in a ragged bite (Fig. 10–2). Trees with thin bark, young stump sprouts, and seedlings are particularly vulnerable. In our study sites in Missouri, herbivory to pin and swamp white oak seedlings primarily consisted of barking, girdling, and shoot clipping by rabbits. Damage to planted oaks was substantially greater in agroforestry plots that contained natural vegetation than those that were planted in a redtop grass (*Agrostis gigantea* Roth; Dugger et al., 2003). In the redtop grass field, 69% of the bare-root seedlings had no rabbit herbivory damage and approximately one-third of them had the main stem clipped. In contrast, 85% of bare-root seedlings were clipped in the natural vegetation field. Of the RPM seedlings in the natural vegetation field, 97% were girdled or had the main stem completely clipped, whereas only 25% were damaged in the redtop grass field.

The Missouri study demonstrates that methods creating a favorable understory condition for rabbits may hamper regeneration efforts in agroforestry plots. Even subtle differences in vegetation structure were important determinants of rabbit density and herbivore damage to tree seedlings (Dugger et al., 2003). Habitat manipulation, however, can control rabbit damage to trees. In the Missouri study, redtop grass cover was not good rabbit habitat in the winter, and planted seedlings were more likely to survive the winter with little herbivory damage from rabbits (Dugger et al., 2003). In areas where rabbit herbivory is severe, fall mowing of natural vegetation to eliminate winter cover may be an alternative to cover, but this needs to be evaluated in future studies. Our radiotelemetry research suggested that even relatively small patches (<10 m$^2$) may contain rabbits (Millspaugh, unpublished data, 2004). Therefore, mowing should be intense and thorough to eliminate rabbit habitat.

There are many other options for minimizing wildlife damage to agroforestry plantings. Rigid plastic mesh tubes have been used with success to limit herbivory to young trees (Black, 1992). Similarly, shelter tubes have reduced rabbit and deer herbivory on a variety of hardwood tree species (Potter, 1988). However, one issue that requires consideration is the microenvironment within the tube (Potter, 1988; Sharrow, 2001). The area within the tube is warmer and more humid during the day (Potter, 1988), which may alter tree performance; compared with mesh tubes. Sharrow (2001) observed higher survival and increased growth of honey locust (*Gleditsia triacanthos* L.) and black locust (*Robinia pseudoacacia* L.) that had shelter tubes. In this case, 60-cm tubes were sufficient to protect against small herbivores, and 180-cm tubes protected trees from deer.

## Wildlife Benefits from Habitat Restoration and Agroforestry

In addition to specific reforestation projects, researchers and managers have explored wildlife response to certain restoration and conservation approaches. While all of these may not have agroforestry as the primary goal, the approaches of these projects might yield insights for wildlife in agroforestry applications. For example, the Farm Bill of 1985 initiated opportunities for wildlife benefits through restoration, including the Conservation Reserve Program (CRP) and Wildlife Reserve Program (WRP) (Allen, 1990; Haynes, 2004; Burger et al., 2006; Gray and Teels, 2006). By 2003, an estimated 600,000 ha were enrolled nationwide in WRP with more than 275,700 ha of the Mississippi River Alluvial Valley enrolled in WRP by late 2005 (King et al., 2006). Many studies have evaluated wildlife response to these activities and agroforestry practices directly. We summarize some of those studies below.

### Riparian Buffer Strips

Stream buffer strips are streamside wildlife plantings of a mixture of grasses, shrubs, forbs, and saplings (Peak and Thompson, 2006). In studies in northern Missouri, Peak and Thompson (2006) found no difference in the number of bird species between wide forests with or without buffer strips, but found that narrow riparian forests with buffer strips contained more species than narrow forests without. They believed that higher numbers of species in narrow forests with buffer strips may have been due to the greater microhabitat diversity found when combining buffer strips with adjacent forest. In the same habitats, Peak et al. (2004) found that songbirds used riparian buffers as breeding habitat, but only one species experienced better nest success in riparian forests with buffer strips. They concluded that for riparian forests in agricultural situations, buffer strips may not necessarily make much difference in providing better songbird breeding opportunities because of the overriding effect of agricultural landscapes on increased nest predation, but indicated that buffers may contribute valuable breeding habitat in some years as long as "source" habitats are available (Peak et al., 2004). These results were supported by Tewksbury et al. (2006), who reported that nest predation increased in forest buffers with more agriculture in the landscape in Idaho and Montana. In Maine, VanderHaegen and DeGraaf (1996) found higher predation in riparian buffer strips compared with riparian forests and recommended buffer strips be >150 m to minimize detrimental effects.

Stream buffer strips also are beneficial to amphibians. In comparing total salamander abundance and amphibian species richness in western Oregon, Vesely and McComb (2002) reported positive benefits from riparian buffer strips. Many other authors have reported benefits of riparian buffers to amphibians (Perkins and Hunter, 2006; Crawford and Semlitsch, 2007). For southern Appalachian streams, Crawford and Semlitsch (2007) recommended a 93-m overall buffer to protect stream amphibians.

In a study of stream buffers, Farrand (2006) found that grass filter strips were used by numerous species of mammals, birds, and reptiles, but believed that reproduction in filter strips, at least for songbirds, was too low to sustain populations. He believed that grass buffers may provide other benefits by providing year-round habitat, and that variation of filter strips with shrubs, forbs, and native grasses could further improve wildlife values (Farrand, 2006). Henningsen and Best (2005) found negative impacts on grassland birds where woody areas were next to stream filter strips and recommended elimination of woody vegetation along streams if grassland songbirds were a management priority. They also found that generalist bird species were most common and that nest success was low, which was largely the result of predation (Henningsen and Best, 2005). Warwick (2003) reported that strip cover was avoided by swamp rabbits (*Sylvilagus aquaticus* Bachman) in southeastern Missouri when compared with agroforestry plots and "natural" remnant forests.

## Cover Crops

In reclaimed strip-mined uplands in Indiana, grasshopper sparrow (*Ammodramus savannarum* Gmelin), Henslow's sparrow (*Ammodramus henslowii* Gmelin), and dickcissel (*Spiza americana* Gmelin) were common in grasslands that had been planted in nonnative grasses over 10 yr previously (DeVault et al., 2002; Scott and Lima, 2004). They indicated that the slowing of succession to forest in the grasslands was likely due either to soil conditions, dominance by nonnative grasses, or distance from forest edge (DeVault et al., 2002). Researchers studying wildlife response to RPM oaks in Lower Missouri River floodplains (Dey et al., 2004) found that use of bottomland old fields by breeding grassland songbird was much longer in plots where a cover crop of redtop grass was used to control invasive vegetation. Henslow's sparrows used fields three summers after planting, while dickcissel and grasshopper sparrows continued to use redtop fields from the first season through at least 5 years after planting. Although stripmines are obviously different from many agroforestry efforts, and nonnative vegetation has often had negative consequences for wildlife and restoration, such findings suggest creative possibilities for combining songbird and silvicultural management objectives. For example, grassland songbird habitat could be provided in the short-to-intermediate term, perhaps through a native cover crop mixture having similar properties to the exotic grasses mentioned above (Scott and Lima, 2004), while wood, pulp, and mast production could result from plantation trees in the longer term. Landowners should also consider the possibility that restorations may act as ecological traps or predator traps if planted in an inappropriate context.

While Van Sambeek and Garrett (2004) did not evaluate wildlife response, they found that use of legume cover crops in plantations led to better growth of hardwood seedlings and saplings compared with plantings with a ground cover of mowed or unmowed weeds. They also found that black walnuts (*Juglans nigra* L.) grew better with some woody cover crops than with managed or unmanaged ground cover alone. Researchers are currently exploring possibilities for native legume and other cover crops, as well as shrubs in hardwood plantations that may provide benefits to quail and other upland wildlife species (J. Van Sambeek, USDA Forest Service, North Central Research Stn., personal communication, 2007).

Native warm-season grasses have demonstrated wildlife benefits. For example, in southwest Pennsylvania, Guiliano and Davies (2002) observed greater bird abundance, species richness, and demographics (i.e., nest survival and fledgling rates) for several birds, including field sparrows, grasshopper sparrows, song sparrows (*Melospiza melodia* A. Wilson), chipping sparrows (*Spizella passerina* Bechstein), and vesper sparrows (*Pooecetes gramineus* Gmelin) within native warm-season grass fields than cool-season grasses. Similarly, Washburn et al. (2000) discussed benefits of native warm grasses to quail and other wildlife in Kentucky. A variety of cover crops thus have demonstrated wildlife benefits. Use of cover crop type (shrub vs. forb vs. warm-season vs. cool-season grass; native vs. non-native) should be considered jointly with likely successional, wildlife, and aesthetic outcomes.

## Shelterbelts

Shelterbelts have a long history of use as a habitat management tool within agricultural settings, with varying degrees of success for wildlife. Shelterbelts (also called "windbreaks") are planted perpendicular to prevailing winds along fields, buildings, and livestock areas to reduce their exposure to winds and thereby reduce wind erosion and evapotranspiration of soil moisture. In addition to providing cover and foraging sites, shelterbelts may provide wildlife travel corridors (Johnson and Beck, 1988). Several authors (Capel, 1988; Johnson and Beck, 1988; Cable, 1991) have discussed wildlife benefits from various shelterbelt designs. Size of the shelterbelt is often considered most important to bird diversity (Cassel and Wiehe, 1980; Schroeder et al., 1992). In eastern Nebraska, Pierce et al. (2001) reported that shelterbelts favor forest-edge and generalist guild bird species, with negative impacts to grassland birds. Similarly, Johnson and Temple (1990) reported increased rates of predation and nest parasitism on grassland birds within tallgrass prairie habitats.

These studies point to problems with adding woody cover to open grasslands—in cases where woody cover exists, grassland birds often are negatively impacted. As a result, several researchers have suggested removing trees in grasslands to reduce predator densities (Winter et al., 2000). However, generalists, such as eastern cottontail rabbits and white-tailed deer are likely to benefit from shelterbelts because of the interspersion of habitats that provide food (e.g., row crops) and cover (e.g., tree plantings; Allen et al., 1996). It is important to consider whether trees should be included in systems (e.g., grasslands) in which they do not necessarily belong.

Diversity and degree of isolation are important factors influencing the utility of shelterbelts. Johnson and Beck (1988) reported that densities and diversity of wildlife may be found in shelterbelts that are larger, with a diversity of structure, including deciduous and coniferous trees, shrubs, and a diverse understory of grasses and forbs. Johnson and Beck (1988) suggested that snags, a well-developed canopy layer, and limiting overgrazing would also promote wildlife benefits in shelterbelts.

## Restoration of Bottomland and Floodplain Forests

Within the discipline of agroforestry there exist many potential benefits for wildlife in bottomland habitats—deer, waterfowl, turkey, and squirrels depend heavily on hard mast such as acorns and pecans (McShea and Schwede, 1993; Norman and Steffen, 2003); soft mast trees such as hackberry (*Celtis occidentalis* L.) provide fruit for wintering species such as cedar waxwing (*Bombycilla cedrorum* Vieillot); even trees and shrubs that do not produce fruit provide habitat structure, a crucial determinant of bird use (James, 1971; Hamel, 2003; Twedt and Best, 2004). Particularly for songbirds, floodplains are valuable habitats for obligate riparian species and for some declining species (Inman et al., 2002). Bottomland locations may provide habitat for a variety of songbirds of conservation interest throughout successional stages, from Henslow's sparrow, which may use early reforesting grasslands, to cerulean warbler (*Dendroica cerulea* A. Wilson), which uses mature bottomland forests, both of which have been petitioned for federal threatened or endangered species listing in the past 10 yr (Burhans, 2001; Burhans et al., 2002). In addition, other birds using floodplains are showing long-term population declines or are considered as Partners-in-Flight "Priority Species" (Rich et al., 2004).

Although many millions of hectares of historically forested floodplain have been lost or converted to agriculture in the 19th and 20th centuries (Abernathy and Turner, 1987; Twedt, 2006, and references therein), recent government incentives and other opportunities have resulted in widespread restoration potential for bottomland forests (Haynes, 2004). The Wetland Reserve Program has led to enrollment of hundreds of thousands of hectares of former agricultural bottomlands in restoration (Haynes, 2004). In the Mississippi Alluvial Valley, an estimated 200,000 ha of agricultural land were replanted in hardwood trees through 2003 (Stanturf et al., 2001; Haynes, 2004). In Missouri, the flood of 1993 resulted in the purchase of thousands of hectares of flood-damaged lands by state and federal agencies (Grossman et al., 2003). With a decade or more of such restoration recently having taken place, it is now possible to begin to evaluate some of the effects of these and related restoration efforts on wildlife.

Inexpensive methods of restoration using minimal site preparation and weed control are required for reforestation of large areas often associated with wildlife habitat (Allen, 1990).

Plantings using direct-seeding, cuttings, and seedlings have been used for various species in the Mississippi River Alluvial Valley (Stanturf et al., 1998). In their study, Stanturf et al. (1998) indicated that bare-root seedlings of 1–0 stock (1-yr old, not transplanted) are suitable for a majority of heavy-seeded and light-seeded plantings. They suggested using cuttings for cottonwood (*Populus deltoides* Bartr. ex Marsh), sycamore (*Platanus occidentalis* L.), black willow (*Salix nigra* Marsh.), sweetgum (*Liquidambar styraciflua* L.), and green ash (*Fraxinus pennsylvanica* Marsh.). Direct-seeding was recommended primarily for oaks and other heavy-seeded species, with "good" success rates (Stanturf et al., 1998). However, Allen (1990), also working in the Mississippi River Alluvial Valley, found that restoration stands in which oaks were planted did better than stands in which they were seeded.

Traditionally it has been difficult to establish hardwood species such as oak, walnut, and pecan [*Carya illinoinensis* (Wangenh.) K. Koch] on productive floodplains due to rapidly growing competing vegetation on rich soils, animal damage, and disturbance through flooding (Dey et al., 2004). Slow growth typically necessitates control of competing vegetation, with animal damage from browsing and deer rubs adding additional problems (Dey et al., 2004). However, larger seedlings having well-developed root systems can increase the likelihood of planting success (Johnson et al., 2002), with recent greenhouse methods resulting in improved root-systems for seedling plantings. The Forrest Keeling Nursery in Elsberry, Missouri, has introduced the RPM method to produce large seedlings with extensive root systems (Dey et al., 2004). The RPM is a trademark for the Root Production Method, an air root pruning process. This approach produces a large container (i.e., either 3- or 5-gallon) seedling. During the past decade, landowners, state conservation groups, and researchers have been planting these seedlings on agricultural bottomlands in Missouri, with generally positive results (Dey et al., 2001; Shaw et al., 2003 Dey et al., 2003; Dey et al., 2004). RPM trees showed higher survival than bare-root seedlings and produced acorns within the first 3 yr of planting (Grossman et al., 2003), some even within the first year after planting (Dey et al., 2001). In addition, RPM oaks showed growth in the first year, whereas bare-root stock showed a decrease in height due to dieback and resprouting (Dey et al., 2001). Where RPM trees are not available, undercutting the taproot during the first or second year, or transplanting 1–0 (1-yr old, not transplanted) seedlings to produce 1–1 seedlings (Johnson, 1988) may produce more vigorous seedlings (Dey et al., 2004). Readers wishing for further details on planting methods should consult the references listed previously, especially Stanturf et al. (1998), Dey et al. (2003), Grossman et al. (2003), and Twedt and Wilson (2002).

Trees growing in Midwest bottomlands typically include light-seeded, wind-dispersed species, such as cottonwood, silver maple (*Acer saccharinum* L.), sycamore, and black willow (Dey et al., 2001). However, oaks (*Quercus* spp.), pecan and hickories (*Carya* spp.), and other nut-producing species are also historic components of floodplain tree communities that were thought to occur on higher elevations subject to less frequent flooding (Dey et al., 2001). Swamp white oak and bur oak (*Q. macrocarpa* Michx.) were present in Lower Missouri and Upper Mississippi River floodplains according to analyses from the early 1800s (Dey et al., 2001, and references therein), and oaks were common enough to be recorded on one-third of survey transects of the Missouri River floodplain in the early 1800s (Bragg and Tatschl, 1977; Dey et al., 2001). In addition to playing important roles as mast-producing trees for waterfowl and deer, oaks are favored foraging spots for spring-migrating and breeding warblers (Graber and Graber, 1983).

While the advantages to wildlife of mast-producing trees such as oaks and pecan may seem self-evident, recent research indicates that wildlife may benefit also from tree species that do not produce fruit commonly consumed by wildlife. Twedt and Portwood (1997) stressed several inherent benefits of fast-growing early successional trees such as cottonwood and black willow in southern bottomland restorations, including rapid return to landowners and enhancement of public perception about the progress of restoration. More substantively, researchers in this system (Twedt and Portwood, 1997; Twedt et al., 2002; Hamel, 2003; Twedt and Best, 2004) have stressed the structural benefits of faster-growing tree stands to forest songbirds. Twedt and Portwood (1997) showed that the early onset of structure in such plantings allowed more songbird species to breed in young cottonwood plantings compared with similarly aged oak plantings, noting 36 species holding territories in cottonwoods compared with only nine species in oak plantings. Similarly, Hamel (2003) noted that for wintering songbirds, twice as many species were present in stands of fast-growing cottonwood plots compared with others; he attributed this to the addition of canopy-dwelling species in the latter stands. In another study, Twedt et al. (2002) noted that oak-dominated stands were not used by forest songbirds until the 10th year after planting. Twedt et al. (2002) recommended planting oaks in combination with rapid-growing trees that promote quick stand development for early use by forest songbirds.

However, in early stages, bottomland restorations may provide habitat for songbirds and wildlife other than those using mature forest habitat. While Twedt et al. (2002) found lowered use of young oak plantings by songbirds overall, they noted that songbirds in the young oak plantings tended to be grassland species, which are considered some of the most important species for conservation (Robinson, 1997). Young oak-dominated plantings had less total "conservation value" for songbirds (as determined by an index using Partners-in-Flight prioritization scores), but birds using young oak stands, especially dickcissel, tended to be high-priority conservation species. Although Twedt et al. (2002) speculated that use of young oak stands by species like dickcissel would similarly occur if stands were simply left unplanted to old field succession, researchers in Lower Missouri River floodplains found that grassland songbird use of unmanaged bottomland old fields was limited to 1 to 2 yr after soil preparation. In contrast, fields planted in oaks using a covercrop of redtop grass were inhabited by grassland birds more than 5 yr post planting. Additionally, the former study showed that oaks planted with the cover crop grew best (Dey et al., 2004). Due to eventual succession and tree growth, oak-planted grasslands would obviously not remain ideal habitat for grassland birds indefinitely. Managers who wish to promote diversity for forest songbirds might wish to consider the recommendations of Twedt et al. (2002) and Hamel (2003). Those who wish to provide habitat for earlier-successional species, such as grassland or shrubland songbirds, could consider adding cover crops or shrubs that suit those wildlife species in the short-to-intermediate term.

One combination approach for establishing an early closed-canopy forest while retaining hard mast would be to plant oaks in combination with fast-growing species such as cottonwood. Stanturf and Gardiner (2000) and Stanturf et al. (2001) suggested the example of interplanting oaks between rows of cottonwood 1 or 2 yr after planting, and then harvesting the cottonwood at 10 yr to release the oaks. Twedt (2006) found that clusters of eastern cottonwood and American sycamore planted within oak plantations led to increased stem density and greater maximum tree heights around clusters; however, this particular study (Twedt, 2006) did not test wildlife response to the cluster plantings.

It should be noted that stands of taller trees may be linked to higher incidence of cowbird brood parasitism. Twedt et al. (2002) found higher abundance of brown-headed cowbird (*Molothrus ater* Boddaert) and greater parasitism rates in older reforesting cottonwood stands compared with oak stands and younger cottonwood stands. Recent findings by Clotfelter (1998), Hauber and Russo (2000), and Saunders et al. (2003) indicated that cowbird parasitism declines with distance from potential perches such as snags or tall trees, which may explain why cowbird parasitism generally appears to be higher in forests in certain landscapes (Hahn and Hatfield, 1995; Burhans, 1997). D. Burhans and B. Root (unpublished data, 2007) also found lowered cowbird parasitism with increased distance to trees in Lower Missouri River bottomland restorations. Presumably, because cowbirds appear to favor plantation forests having taller trees over other habitats, increases in cowbird abundance and parasitism such as these are not specific to the tree species planted. However, factors of scale also need to be considered in relation to cowbird parasitism and nest predation because studies have shown that regional and landscape effects, such as amount of regional forest cover, may constrain parasitism at lower scales (Donovan et al., 2000; Thompson et al., 2000).

Species of conservation concern including various bat species and swamp rabbits may benefit from agroforestry sites in bottomland forests. In southeastern Missouri, more bats were captured per hectare on agroforestry sites (0.310 $h^{-1}$) compared with "natural" forest (0.204) and strip cover sites (0.217 $h^{-1}$) (Warwick, 2003). Mean species richness for bats was also greater within agroforestry sites (4.61 $h^{-1}$) compared with "natural" forest (4.39 $h^{-1}$) and strip cover sites (3.84 $h^{-1}$) (Warwick, 2003). Based on latrine site locations, Warwick suggested that swamp rabbits use agroforestry sites for food and natural forest remnants for other activities (e.g., loafing and resting; Warwick, 2003). He concluded that at his study site agroforestry plantings were an important habitat component for swamp rabbits.

## Greentree Reservoirs

Under conditions such as greentree reservoirs, managing oaks for mast production can provide feeding areas for waterfowl (Fredrickson, 1980; Fredrickson and Heitmeyer, 1988). Many areas, particularly in the south, are managed for greentree reservoirs to promote timber and waterfowl habitat; greentree reservoirs also occur in northern states such as New York (Deller, 1997). In a review of greentree reservoir management, Wigley and Filer (1989) reported that most greentree reservoirs were <100 ha in size, dominated by oaks, and provided <100 d of hunting. In these situations, bottomland hardwood forest stands are typically flooded every year. Flooding begins in the fall and stops at the end of the waterfowl hunting season. At the end of the hunting season, the areas are drained. The flooding attracts waterfowl, such as mallards (*Anas platyrhynchos* L.) and wood ducks (*Aix sponsa* L.), because of the availability of fallen acorns and other seeds during the hunting seasons. Additionally, invertebrate densities may increase in greentree reservoirs compared with naturally flooding bottomlands (Werhle et al., 1995). Often water control structures are installed to aid water management. Greentree reservoirs are typically managed so the area is flooded when the trees are dormant; however, in some areas, some trees are not dormant when flooding starts (Guttery and Ezell, 2006), which can result in the loss of mature trees. In southeastern Missouri, greentree reservoir managers are trying to mimic the natural hydrologic cycle in an attempt to keep trees drier during the growing season (Krekeler et al., 2006).

Some studies have investigated wildlife use of greentree reservoirs, and the majority of those studies involve waterfowl. In Arkansas, Christman (1984) reported that birds that forage in the understory were absent or in reduced density in greentree reservoirs compared with control plots. Birds that typically use the overstory canopy to forage were found in equal or higher densities than in control plots (Christman, 1984). These results led Christman (1984) to conclude that greentree reservoirs will typically have lower densities of nongame birds than nonmanipulated habitats. It is generally agreed that greentree reservoirs are beneficial to wintering waterfowl, particularly during years when flooding does not occur (Rudolph and Hunter, 1964). Wood ducks and mallards in particular use greentree reservoirs extensively during the winter (Fredrickson, 1978; Fredrickson and Heitmeyer, 1988; Kaminski et al., 1993). There are also associated waterfowl harvest benefits to greentree reservoirs (Rudolph and Hunter, 1964). Thus, there is a potential for income generated through lease hunt opportunities in bottomland situations. However, one must also consider potential impacts to timber production.

There are many adverse effects of greentree reservoir management to timber production, such as increased tree mortality, decreased mast production, reduced regeneration, and altered species composition (Wigley and Filer, 1989; Deller, 1997). For example, in Mississippi (Allen, 1980) and Arkansas (Guttery and Ezell, 2006) managers noted an increase in the density of overcup oak (*Quercus lyrata* Walt.), a tree that is not commercially valuable; it also produces acorns which are not preferred waterfowl foods (Allen, 1980). Such issues have caused some (Young et al., 1995) to suggest a 2-yr flooding cycle or even longer depending on tree species objectives. Thus, when considering the integration of agroforestry with greentree reservoir management, there are additional challenges associated with timber management and the potential to kill trees before they mature and become harvestable.

## Lease Hunting Opportunities

Agroforestry systems often contain a combination of forestry and traditional agricultural management activities. In these situations, landowners supplement their income during the early stages of timber establishment by planting annual row crops or cereal grains between rows of young trees (e.g., alley cropping; Garrett and Buck, 1997). Specific agricultural crops can be planted and manipulated to attract and concentrate wildlife. In other words, a landowner implementing an agroforestry program may wish to also incorporate a wildlife management habitat program (Leopold, 1933; Allen, 1954; Dickinson, 1993). Many landowners may find their wildlife habitat management activities actually increase and diversify farm income through the leasing of hunting rights.

Landowners willing to invest in wildlife habitat management and expend the energy in establishing pay-to-hunt arrangements can often generate an immediate revenue stream while waiting for timber harvest. Depending on location, hunting lease income may often pay annual property taxes with some money left over (Kays, 2000). However, there are several challenges for the landowner to consider before implementing a pay-to-hunt operation or lease hunting. Most importantly, a landowner must have reasonable and flexible expectations. The type and quantity of game animals depend on the existing local conditions (e.g., surrounding landscape conditions), and the available type and quantity of game species will evolve as the agroforestry trees move through different successional phases and change the surrounding habitat (Fig. 10–1). Also, the most profitable pay-to-hunt operations are often the most labor and management intensive for the landowner. Our objective, therefore, is to provide a brief description of the range of available lease hunting options, considerations for establishing hunting leases, and then focus specifically on the example of establishing mourning dove hunting leases in an agroforestry complex.

## Hunting Leases and Pay-to-Hunt

Depending on locale or tradition, there are many names given to situations where hunters purchase or exchange commodities to obtain trespass rights from a landowner. A few examples include *pay-to-hunt operations, game farms, hunt clubs,* or *game leases*; the most commonly used term is *lease hunting*. With lease hunting, every farm or ranch is different within the context of the landowner's long-term and short-term agroforestry goals, habitat quantity/quality, available game species, game abundance, and local legal restrictions. Although lease hunting has been more popular in southern states and states containing minimal public hunting lands, it is becoming more popular across the entire United States as landowners look for greater income diversity (Masters et al., 1996) and hunters desire unique, predictable, or more high quality hunting opportunities (Miller and Vaske, 2003; Schulz et al., 2003). Gentle et al. (1999) suggested that private landowner attitudes toward recreational access depended on differences resulting from the particular regional ancestry of the people.

To be effective and have the greatest financial return, lease hunting opportunities tied to agroforestry programs need to provide opportunities for willing participants. For example, providing opportunities near expanding urban and suburban sectors of the population would be advantageous (Schulz et al., 2003). This is an important consideration for a successful venture because most hunters live in or near urban areas, and these urban residents have multiple demands on their available leisure time (Cordell and Betz, 2000). Survey data show that remaining upland bird hunters travel farther and farther from home and make numerous trips out of state to find suitable hunting opportunities (Duda et al., 1998; Brown et al., 2000). For those who hunt, hunting related expenses have increased significantly in recent years (Brown et al., 2000). Regardless of how much hunting related expenses have climbed, most hunters cite the lack of free time as a primary consideration for their continued participation in hunting activities (Duda et al., 1998; Cordell and Betz, 2000). Along with a decrease in discretionary free time, public hunting land is increasingly overcrowded, especially in states with little public land (Schulz et al., 2003). In addition, as smaller traditional working farms are consolidated into larger corporate farms or subdivided into smaller rural estates outside of a major metropolis, opportunities to hunt free on private lands are rapidly diminishing. Most hunters, private landowners, and state fish and game staff are just beginning to appreciate the importance of fee hunting to the future of hunting overall. Fee hunting could become a more important tool to help slow or reverse the long-term decline in hunter numbers (Brown et al., 2000) by providing additional hunting related outdoor opportunities (Cordell and Betz, 2000; Cordell and Super, 2000).

The second most important factor determining success of the lease hunting endeavor is the "quality" of the experience provided by the landowner. Depending on the hunters needs, quality may be defined multiple ways. Although difficult to define specifically, a quality lease hunting experience may consider one or more of the following items: cost of the lease, proximity to where hunters live and travel time to leased land, abundance and/or variety of game animals, real or perceived competition with other hunters, availability trophy class animals, hunter safety, opportunities for companionship or fellowship, facilities to clean game animals, amount of hunter restrictions, camping or lodging facilities, and numerous others.

Third, a landowner should plan in advance for changing leasing opportunities throughout the timber rotation component of the agroforestry operation (Fig. 10–1). Early during tree establishment, the landowner will have greater opportunities to focus on small game species (e.g., mourning doves) that can be legally concentrated using managed lure crops like sunflowers (*Helianthus* spp.). As the trees grow and agricultural land becomes more shaded by the timber, hunting opportunities will begin to shift away from early successional game animals to species like wild turkey or white-tailed deer along with a decrease in the intensity in management of wildlife habitat.

## Types of Hunting Leases

Although popular among many hunters and landowners, an informal oral hunting agreement often leads to misunderstandings and potential legal difficulties later. A signed and professionally prepared legal document stating all the payments, terms, expiration dates, and mutual agreements is the best way to ensure that the rights and privileges of the hunter and landowner are understood by all parties (Stribling, 1994). In other words, pay hunting is a business, and a hunting lease is a business arrangement outlining the terms of the agreement.

A hunting lease is usually defined as an agreement between a landowner and a hunter (or group of hunters) where the right to trespass and hunt is granted for a particular time and fee (Masters et al., 1996). It is a simple business agreement between the person who owns and controls the land and another person who wants to use the land, or it can be a complex legal document requiring professional assistance and development. It can take numerous forms, ranging from an informal oral agreement and a handshake to a clear and explicit legal document signed before a notary public. General categories include non-fee access, an exchange of services, a daily hunting lease, short-term or seasonal hunting lease, annual or multi-year lease, and broker/outfitter lease (Stribling, 1994; Masters et al., 1996; Rempe and Simons, 1999).

## Non-fee Access

This arrangement provides access to land for hunting with informal verbal or written permission; it is the easiest and often the first option for many landowners. For the landowner, this option may help manage nuisance animal populations (e.g., white-tailed deer) and help foster goodwill in the local community. Also, the reduction in deer populations may help provide a corresponding reduction in damage to agroforestry plantings, particularly those early in development. These ad hoc arrangements provide several nonmonetary landowner benefits, such as reduction in vandalism because of increased presence on rural land, potential help with seasonal farm work, and increased social networking. These arrangements are often more common in rural or rural small town areas where hunters are more aware of farm-related issues and concerns.

## Exchange of Services

Using different words, this could be called a *quid pro quo*, where something is given in return for something else. As the name implies, this type of arrangement allows hunting in exchange for monitoring the land for trespassers or helping with farming operations (e.g., bailing hay, fixing fences, or posting signs). Without money changing hands, both parties benefit by exchanging or bartering services with each other. The major difference between exchange of services and non-fee access is the explicit expectation of rendering a specific service by the hunter for the privilege to hunt. These arrangements can be informal or formal agreements.

## Hunting Lease Types

Masters et al. (1996) and Mozumder et al. (2007) describe four general groups or categories of fee or lease hunting:

**Daily Lease.** Daily leases work best for hunting situations with a relatively short season that can accommodate numerous hunters on a relatively small patch of ground (e.g., mourning dove hunting or pen-reared bird hunting). Daily leases are much more labor intensive for the landowner (Kays, 2000), but have greater opportunity for increased income. As mentioned previously, daily lease (known in some areas as "daily trespass fees") requires more interactions with more hunters, along with greater intensity of wildlife habitat management to ensure the game animals are available on opening day of the season. Also, given the short duration of many of these types of opportunities, landowners should consider advertising to ensure enough paying hunters cover management expenses (e.g., advertisement in the sports section of a major metropolitan newspaper).

**Short-Term or Season Lease.** Short-term or seasonal leases work best for deer or turkey hunting and involve considerably less direct or immediate land or hunter management by the landowner. The landowner may wish to have separate leases for different seasons and game species and for different groups of hunters. The agroforestry landowner must remember to specify in the lease that hunters should not use screw-in type tree climbing steps or tree stands, which may damage the eventual value of the trees on the property. An alternative is to recommend only free-standing or portable tripod-type hunting blinds. Also, remember to specify whether shooting lanes will be cleared or brush removed around stands or blinds. Other considerations to outline in the seasonal or short-term lease include use of baiting or automatic game-feeders, restricted use areas for all-terrain vehicles (ATVs), and the number of guests allowed per lessee. With multiple lessees, it is also necessary to specify how land is divided among the clientele.

**Annual or Multi-year Lease.** Annual or multi-year leases usually involve an agreement between a single landowner and a hunt club or group of friends willing to share the cost of having a long-term hunting spot available. Over several years the hunt club may begin to share a feeling of ownership with the landowner and may participate in some of the required wildlife habitat management activities. In these types of longer-term arrangements the landowner may request that harvest records be kept according to number and sex of animals taken, time and date, weather conditions, location of kill, body weight, and/or antler score if appropriate.

**Broker or Outfitter Lease.** Broker or outfitter leases involve a middle-man or broker that rents all the hunting rights from a landowner (or series of landowners) and subleases to individual hunters by species or season. For many landowners it is easier to deal with one individual who then manages (or sub-leases) all the hunting related details of the lease hunting opportunities to individual hunters (e.g., LeaseHunting.com, *Hunting Lease Magazine*). Several nongovernmental organizations provide this service (e.g., Quail Unlimited), along with numerous private organizations or networks of landowners (Lease Network).

## Liability and Insurance

Although land ownership is less of an objective of many U.S. citizens today, private land ownership is an important component of our American heritage. Outdoor recreation is still a major part of our culture, and access to private land plays a critical role now and into the future. Attitudes toward private land access, however, appear to vary regionally based on the cultural differences and amount of available recreational public lands (Gentle et al., 1999). Landowners also have numerous concerns about allowing access to their lands, including a history of past problems or negative perceptions about recreational users, proximity of residence to location of recreational activities, illegal hunting activities, personal safety, inconsistencies with long-term land management objectives (e.g., agroforestry, crop farming, ranching), landowner concern over certain recreational activities (e.g., hunting, ATV trail riding), and potential liability issues (Wright and Kaiser, 1986; Wright et al., 2002; Jagnow et al., 2006; Zhang et al., 2006). Despite the long list of landowner concerns about granting access to their lands, the primary and overriding concern is the fear of being sued or held liable for injuries sustained while on the land (Wright et al., 2002; Jagnow et al., 2006). The most often used justification by landowners for restricting access to their private land is the potential threat of liability (Brown et al., 1984; Wright et al., 2002; Mozumder et al., 2007).

Common-law tort and property law regulate a landowner's obligations to recreational users of private land. Most states, however, currently have laws limiting a landowner's liability when access to private property is granted without a fee (Wright et al., 2002; Mozumder et al., 2007). In most cases, however, the liability protection is limited when a fee is charged. Under most state laws, the degree of landowner liability is dependent on the status of the visitor or user (i.e., trespasser, licensee, or invitee; Copeland, 1998; Wright et al., 2002). Among the three groups, invitees have the greatest legal protection, licensee moderate protection, and trespasser little to no protection. An invitee is a person expressly or implicitly invited on the property by the landowner for a public or business purpose. The landowner is not required to guarantee the safety of the invitee, but only provide a reasonable effort to prevent risk. A licensee is anyone who enters the property by permission only, without any inducement to the landowner. This is generally a social guest of the landowner and not economically beneficial to the landowner. A trespasser is someone who is on another's property without permission, authority, or invitation of the landowner; the landowner's primary obligation is to avoid actively harming the trespasser. Depending on the state, the category designation of the user is important because the specific category establishes the legal obligations of the landowner.

Although the myth and perception of landowner liability appears to be greater than the actual risk (Wright et al., 2002), the issue should not be handled in a cavalier fashion. Given the variety of legal differences among states (Gentle et al., 1999; Wright et al., 2002), a qualified lawyer and insurance agent should be consulted before entering into any hunting lease agreement or purchasing liability insurance. Local resource management professionals and university extension specialists, while offering free advice about basic aspects, may not be aware of the complexities and intricacies of landowner liability statutes.

## Mourning Doves and Hunting Leases

What do agroforestry, mourning doves, and lease hunting have in common? Together, they have the potential to optimize and diversify the return on a landowner's investment in agroforestry settings. Like any investment opportunity, however, there are no guarantees. In contrast to other financial investments, return rates are often directly linked to the investment of a landowner's time, energy, and commitment. The following section describes how doves, agroforestry, and lease hunting can make a meaningful and unique financial contribution to the landowner, assist in the perpetuation of the North American hunting tradition, and ensure the sustainable production of high quality timber products.

Mourning doves are the most heavily hunted and harvested migratory game bird in the United States (Dolton and Rau, 2006). Despite this high hunting pressure, they are also one of the most numerous songbirds in North America (Robbins et al., 1986; Tomlinson and Dolton, 1987; U.S. Fish and Wildlife Service, 2005). Harvest management responsibility is conferred to the U.S. Fish and Wildlife Service (USFWS) by the Migratory Bird Treaty Act of 1918, with decisions being made cooperatively with state wildlife agencies through the flyway council system (Reeves, 1993; Dolton and Rau, 2006). Annually the USFWS establishes mourning dove hunting season regulations for each of the three mourning dove management units (Fig. 10–3). Within the federal hunting season frameworks, states may select more restrictive hunting regulations, but not more liberal (Reeves, 1993).

One of the primary reasons mourning doves are such a ubiquitous and abundant species is that they are habitat generalists that use almost every major ecological habitat type in North America (Aldrich and Duvall, 1958; Lewis, 1993; Sayre and Silvy, 1993). Mourning doves are also multiple nesters, requiring roughly 30 d between initiation of a successful clutch and the initiation of a subsequent clutch (Sayre and Silvy, 1993; Mirarchi and Baskett, 1994). In some latitudes mourning doves nest year-round. Another reproductive advantage allowing mourning doves high annual recruitment is the use of crop milk to feed young squabs in the nest (Mirarchi, 1993). Crop milk provides a reproductive advantage by allowing doves to rear their altricial young year-round with a high protein diet as long as grain or weed seeds are available.

Mourning doves provide numerous advantages when considering lease hunting opportunities in combination with an agroforestry program. The birds are primarily granivorous ground feeders, preferring bare ground and relatively open areas devoid of rank vegetation (Lewis, 1993). This feeding characteristic of using relatively open areas is complementary to early establishment of agroforestry plots. The open land between tree plantings can be specifically planted to lure crops to attract feeding mourning doves rather than growing other traditional agricultural crops for market.

Mourning doves take advantage of a wide range of weed and cultivated seeds, preferring small, even tiny, seeds (Lewis, 1993). Examples of nonagricultural seeds found in mourning dove crops include pigweeds (*Amaranthus* spp.), spurges (*Euphorbia* spp.), crotons (*Croton* spp.), goosefoots or lambsquarter (*Chenopodium album* L.), panic grasses (*Panicum* spp.), foxtails (*Hordeum* spp. and *Setaria* spp.), barnyard grass (*Echinochloa crusgalli* Beauv.), other grasses (e.g., *Poa* spp., *Paspalum* spp., and *Brachiara* spp.), ragweed (*Ambrosia* spp.), and poke or pokeweed (*Phytolacca americana* L.; Mirarchi and Baskett, 1994; Tomlinson et al., 1994). Agricultural crops, however, are likely more important food sources across the dove's range; when available, they comprise >50% of the food volume in the crop (Lewis, 1993). Favorite agricultural crops include corn, wheat (*Triticum aestivum* L.), grain sorghum (*Sorghum vulgare* Pers.), various millets (*Panicum* sp. L.), buckwheat (*Fagopyrum sagittatum* Gilib.), peanuts (*Arachis hypogaea* L.), canola or rapeseed (*Cruciferae* sp. L.), and sunflower (*Helianthus annuus* L.).

## Dove Management and Sunflowers

Although mourning doves opportunistically feed on a wide variety of weed seeds and agricultural crops, sunflowers are undoubtedly the primary gold standard of lure crops for reliably attracting doves. Concerning lease hunting specifically, a landowner wants to reliably attract mourning doves each year, which often results in a clientele

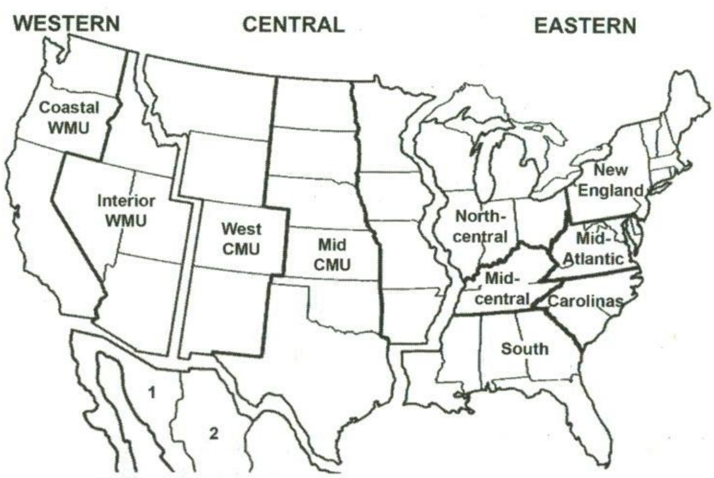


**Fig. 10–3. Within the United States, there are three zones, or management units, that contain discrete mourning dove populations that are roughly independent of each other. These zones encompass the principle breeding, migration, and U.S. wintering areas for each population. Hunting season regulations and frameworks are annually established by management unit in cooperation with the U.S. Fish and Wildlife Service and state wildlife management agencies. (CMU is central management unit.)**

of satisfied hunters. Although other crops work with various degrees of success, sunflowers have been shown to be a consistent attractant for local and migrating mourning doves.

The ideas behind mourning dove field shooting management are conceptually simple. First, the sunflowers are planted early in the growing season so the crop is available at least 4 to 6 wk before the opening of the hunting season. As summer progresses and the sunflower seeds become available on bare ground, local doves will begin to congregate around the field to feed. With a constant and consistent food supply, mourning doves will remain around the field(s) throughout late summer and early fall, regardless of any cold fronts passing through the area.

Second, the sunflower plants and remainder of the field must be managed to eventually provide a situation where the majority of the hunting field is bare ground covered with nothing but sunflower seeds, with the field edges consisting of a few rows of standing sunflowers to conceal hunters. Given precipitation during the summer, weeds (e.g., ragweed) will begin to decrease the openness of the field and sections of the field will need to be mowed, disked, or plowed to keep the bare soil component available. Specific details about planting, cultivating, and mowing sunflowers are provided in the appendix.

Although sunflower management is labor intensive, the landowner has an opportunity to derive significant additional income from a daily-use fee hunting operation with 10 to 12 hunters $ha^{-1}$ killing 50 doves $ha^{-1}$. Depending on local conditions, the effective season length would last 1 to 5 d (Missouri Dep. of Conservation, unpublished data, 2007). Given roughly 3 d of hunting on a 4-ha managed sunflower with 50 hunters paying $25.00 on Day 1, 25 hunters on Day 2, and 10 hunters on Day 3, a landowner could obtain $2,125 in daily-use fees. The costs associated with planting, herbicides, cultivating, and mowing a managed sunflower field would be similar to planting and harvesting a soybean crop.

## Considerations for Private Operators

**Effective Season Length.** For all practical purposes, mourning dove hunting is a relatively short hunting season. Although some exceptions have demonstrated significant dove harvest over a 30-d period, there is also a hunter perception issue. Most managed fields run out of doves and/or hunters start to lose interest after a few days; 72.4% of dove hunters make one trip per season, 19.4% make two trips, and 5.0% make three or more trips per season (Fig. 10–4).

**Baiting.** Similar to misunderstandings and misinformation about landowner liability in lease hunting agreements, there exists considerable misunderstanding and misinformation about dove field shooting management and legal restrictions on baiting. In addition to misunderstandings about the definition of baiting, the issue is also one of the most common law enforcement problems associated with dove hunting. Part of the confusion rests with differences between federal baiting restrictions for waterfowl and mourning doves. According to federal and most state laws, no person shall take or attempt to take migratory game birds by the aid of baiting or on or over any baited area. Baiting is placing, exposing, depositing or scattering salt, corn, wheat or other grain, or any feed that may lure or attract doves to or over an area where hunters are attempting to harvest them. Any area where bait has been placed constitutes a baited area. A baited area is considered baited for 10 d following the complete removal of the bait because doves will habitually return to a feeding area for a few days after the bait has been removed.

Doves may be legally hunted over a standing crop or any field where any grain, feed or salt has been distributed or scattered as a result of agricultural operation. This includes lands planted as wildlife food plots, providing that the seed is planted in a manner

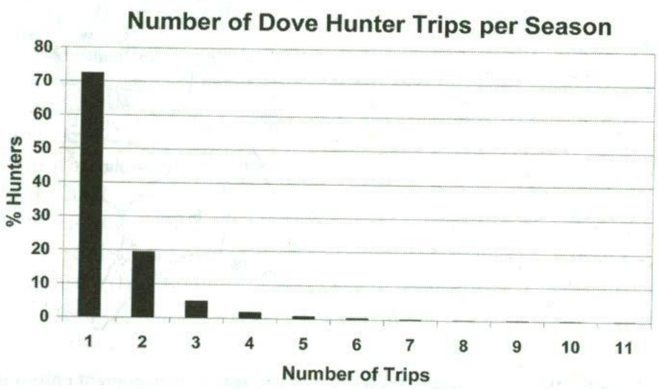


**Fig. 10–4. Number of hunting trips made by Missouri hunters estimated by matching conservation numbers recorded on daily hunt cards during September 2006 on 12 areas specifically managed for mourning dove hunting opportunities (Missouri Dep. of Conservation, unpublished data).**

consistent with the recommendations for planting. Standing crops may also be manipulated by any method to attract doves such as mowing, disking, or burning so long as it is not harvested and then redistributed on the field. Also, livestock may be used to manipulate a dove field by allowing them to enter a field and feed on standing or harvested crops; this practice is more common in southeastern states.

Doves may be hunted over topsown winter wheat, but the seeding rate must be in accordance with standard or normal agricultural practices outlined by the state agricultural authorities. In cooperation with the U.S. Fish and Wildlife Service, state resource management agencies (or state DNR) usually recognize the state cooperative extension system as the authority on what is considered a bona fide or normal agricultural operation. The local county extension office often has free publications explaining proper farming practices and techniques. Following is an example of the guidelines provided Alabama Cooperative Extension System stating that top sowing wheat is a normal agricultural practice for establishing a cover crop in low-input management systems (Alabama Dep. of Conservation and Natural Resources, unpublished data). The practice requires a well prepared seedbed with good soil-to-seed contact and a bona fide attempt be made to cover seed by cultipacking, disking, or raking; some incidental seed may remain on the surface following a bona fide covering attempt. Also, all small grain planting should adhere to planting dates recommended in printed tables furnished by the Alabama Cooperative Extension System with a recommended seeding rate of ≤225 kg $ha^{-1}$ with seeds uniformly distributed.

**Advertising, Amenities, and Fees.** Depending on the number of hectares managed for dove hunting and location of the fields relative to urban areas, advertising may need to be a consideration. In rural areas, word-of-mouth among neighbors may be sufficient to provide enough paying hunters to cover management costs along with a minimal profit. However, the greatest financial gains will occur when the greatest number of hunters can be accommodated near urban communities, and money spent on a few newspaper advertisements may help attract hunters. On public dove shooting fields in Missouri, for example, 5 to 10 hunters $ha^{-1}$ $d^{-1}$ can be safely accommodated (Missouri Dep. of Conservation, unpublished data, 2007). In these situations, advertising will be necessary to attract hunters willing to pay extra for the hunting experience provided. Given the relatively short-term nature of the dove hunt, reservations and prehunt payments may be necessary to ensure hunters actually show up to hunt or to prevent the presence of too many hunters creating a less than enjoyable hunting experience.

One of the greatest uncertainties for the landowner of managed dove fields is the question of fee. Unlike other hunting lease situations (e.g., big-game lease hunting) where the hunting opportunity is usually leased on a flat per hectare basis on a seasonal or annual cycle, managed dove hunting is more profitable with a daily charge of \$20 to \$50 $d^{-1}$ $hunter^{-1}$. As the number of doves using the field(s) declines, the landowner may charge less per hunter.

**Voluntary Nontoxic-Shot Requirement.** For several centuries lead has been a well-known environmental poison affecting the health of wildlife (Locke and Friend, 1992; Beyer et al., 1996; Locke and Thomas, 1996). Feeding doves may ingest lead shot from managed dove fields because the spent shotgun pellets appear similar to weed seeds and grain (Conti, 1993; Mirarchi and Baskett, 1994; Kendall et al., 1996). On 14 managed public hunting areas in Indiana, the mean density of lead shot, post-season, was 27,515 pellets $ha^{-1}$, a 645% increase from pre-season soil estimates (Castrale, 1989). Using similar soil sampling protocols, post-hunt shot densities in Missouri were 6342 pellets $ha^{-1}$, a 1697% increase from pre-season sampling estimates (Schulz et al., 2002). Lead pellet ingestion rates for hunter-killed mourning doves vary from <1.0 to 6.5% depending on locale (Conti, 1993; Mirarchi and Baskett, 1994; Kendall et al., 1996; Schulz et al., 2007). Considerable information exists demonstrating that dove hunters deposit large quantities of spent lead shot around favorable hunting locations, some proportion of doves ingest lead pellets while feeding on hunted fields, and most doves ingesting lead pellets eventually die from the immediate or secondary effects of lead poisoning (Schulz et al., 2006). Other wildlife species might similarly ingest lead and die. A responsible landowner establishing a managed dove field should consider implementing a voluntary nontoxic-shot requirement on their land given the available information.

**Leasing to State Game and Fish Agency.** Operating a private dove hunting lease can be a daunting task for an agroforestry landowner given the work associated with managing the lure crop during the summer and hunter management during the hunting season. However, an innovative alternative has been developed in Kentucky that creates a beneficial partnership for landowners, hunters, and the state wildlife agency. Initiated in 1998, the program has increased mourning dove hunting opportunities by leasing managed dove fields from private landowners, with an emphasis on lands close to major metropolitan areas. In cooperation with a local wildlife biologist, landowners can get reimbursed as much as $2,500 in just a few days of hunting; most fields are 4 to 8 ha. Payments are based on number of hectares and crop type. Normal "up front" agricultural costs are the landowner's responsibility. A portion of the payment is reimbursement for planting costs (i.e., seeds, chemicals, fuel, etc.). Actual payment amounts are based on the number of hectares enrolled and crop type and are specified in the initial agreement. Participation in the Kentucky program does not affect landowner liability. A legal agreement is signed by the landowner and local biologist stating the landowner will allow hunters on their property and that they will plant and manage the respective fields as prescribed in the agreement. Normal agricultural costs are the landowner's responsibility. In the event of crop failure, the landowner is reimbursed for the planting costs.

## Cost-Share Opportunities

Cost-share programs for wildlife often support specific habitats and their associated traits. Funding assistance for specific habitat comes from one of three sources: federal, state, or private. In recent history, the majority of support of conservation practices has arisen from federal sources associated with federal farm programs. While many of the programs and practices are outside the bounds of our traditional definitions of agroforestry practices, a goal is to successfully integrate wildlife species with agronomic production. Cost-share programs and practices that have typically not allowed the production of harvestable products can provide a means of developing and maintaining habitat components in conjunction with farming practices. Their merit should be viewed as extending beyond the primary resource that they are designed to conserve (soil, water, etc.) and be broadened through intentional design to provide specific habitat needs that are otherwise missing from agricultural landscapes. Numerous benefits to a diversity of wildlife species have been discussed (Johnson, 2005; Reynolds, 2005; Farrand and Ryan, 2005). We encourage landowners to obtain specific information on cost-share programs within their state. For example, for landowners in Missouri, Godsey (2005) developed a publication describing funding incentives for agroforestry in Missouri. Several of the federal programs are briefly summarized below.

### Federal Programs and Practices

Two federal agencies provide a majority of the support for conservation practices, and both fall under the broader jurisdiction of the USDA. The USDA Farm Service Agency (USDA-FSA) administers the Conservation Reserve Program (CRP), the Conservation Reserve Enhancement Program (CREP), as well as other lesser known conservation programs. The USDA-NRCS administers the Environmental Quality Improvement Program, Wetland Reserve Program, Wildlife Habitat Improvement Program, and other conservation programs. Both agencies, and the programs they support, receive funding under the congressionally enacted Farm Bill and interact with one another to support and promote various conservation programs. In particular, recent versions of the Farm Bill have been enhanced with respect to conservation programs that support wildlife (Heard et al., 2000). The programs of the Farm Bill are connected to farming by the stipulation that qualifying lands have a cropping history. Over time this cropping history has been broadly defined and has ranged from necessitating proof of row-cropping history to more lenient definitions that allowed pasture land to qualify.

#### USDA–FSA Programs

One of the longest running federally supported programs has been the CRP (Best et al., 1998; Farrand and Ryan, 2005). Included within CRP are numerous conservation practices, including the agroforestry practices of windbreaks (Conservation Practice [CP] 5), shelterbelts (CP16), and riparian buffers (CP22). Also included are numerous practices that support wildlife enhancement and conservation, including wildlife food plots (CP12), shallow water areas for wildlife (CP9), and upland bird habitat buffers (CP33), to name a few. In addition to CRP, USDA-FSA has several other programs that may be used to create or maintain wildlife habitat. These include the Conservation Reserve Enhancement Program (CREP), Bottomland Timber Establishment on Wetlands Initiative (under CRP), Duck Nesting Habitat Initiative (under CRP), and the Grassland Reserve Program (http://www.fsa.usda.gov).

#### USDA–NRCS Programs

While the USDA-FSA administers the CRP program, the USDA-NRCS offices often provide the technical support to farmers and recreational landowners wishing to design a

CRP conservation practice. In addition to their technical support to CRP, there are also several programs within the Farm Bill for which USDA-NRCS is specifically responsible to support and administer: the Conservation Security Program (CSP), Wildlife Habitat Incentives Program (WHIP), Wildlife Reserve Program (WRP), Grassland Reserve Program (GSP), and Environmental Quality Incentives Program (EQIP) (http://www.nrcs.usda.gov). Amid these programs, WRP and WHIP have used specific wording to emphasize the conservation potential in support of wildlife (USDA-NRCS, 2004). EQIP practices have also been effectively used and tailored in support of wildlife.

### Private Programs and Support

Over the years, several nationally recognized private groups have been organized to provide support for wildlife habitat management activities. A few of the prominent national groups include National Wild Turkey Federation, Quail Unlimited, Ducks Unlimited, and Pheasants Forever. The main focus of these groups is habitat development, management, and maintenance for the wildlife species of interest. Often support is provided by placing interested landowners in contact with professionals, such as private land biologists working for the state, who will assist in designing habitat appropriate to those landowners' needs and desires, or provide additional cost-share incentives for specific practices (e.g., establishment of native warm-season grasses). In addition, these private groups often have seed mixes available at reduced costs and provide cost support for the development of local wildlife habitats.

## Recommendations for Providing Wildlife Benefits

Based on the general considerations, we offer the following advice to those interested in promoting general wildlife benefits within agroforestry settings. If a landowner has refined, species-specific objectives (e.g., managing specifically for white-tailed deer), management of agroforestry plantings should be tailored for that species. In such cases, we recommend landowners consult with references for that species (e.g., Walter and Pierce, 2007). The recommendations below are general in nature and are designed to increase overall wildlife benefits and diversity.

### 1. Establish realistic goals.

When considering wildlife benefits in an agroforestry context, a landowner must remember that not all wildlife will benefit from their practices. For example, alley cropping and windbreaks might create edge that will benefit white-tailed deer, but other species such as neotropical migrants might not benefit. Such tradeoffs should be considered when there is a goal of improving wildlife benefits. Also, because wildlife benefit objectives are often secondary to timber production, there are limitations to wildlife benefits that can be attained. In other words, changes to tree species selected and planting options are somewhat limited given logistical and economical constraints.

Additionally, the scale of the agroforestry operation has an important impact on the realized wildlife benefits. Whereas a 5-ha agroforestry field might result in the harvest of a few hundred mourning doves if planted to sunflower, one cannot reasonably expect the same number of quail to be harvested within that area. Wildlife benefits are attainable with minor alterations to the timing of planting, cover crop management, shrub selection, tree spacing and configuration, and other factors, but setting goals will help a landowner better determine proper management methods and reach their objectives. Another consideration is that some wildlife may cause tree damage (e.g., rabbits and deer) and may be counterproductive to the long-term timber management objective.

### 2. Promote structural diversity and manage habitat edges.

In general, wildlife will be benefited by creating "soft" boundaries, promoting plant diversity (i.e., tree selection, cover crop, shrub selection), increasing the overall width of plantings within and between rows ,and offering diversity in ages of plantings (Fig. 10–5). Slight alterations such as changing spacing of tree plantings within a row could help improve cover and reduce predator success due to increased visual obstruction. Widening plantings also improves understory production by allowing more light to reach the ground; such increases could improve habitat quality for ground nesting birds and improve cover for species such as bobwhite quail. Mixed species composition would greatly enhance within-stand diversity, but it does require careful planning to ensure shade tolerant plants are mixed appropriately with shade-intolerants (Allen et al., 1996). Creating soft boundaries may provide several advantages over hard boundaries by increasing the variety of vegetation, diversity of horizontal structure and the overall amount of habitat available. An example of a change in traditional alley cropping planting could include the incorporation of a native grass strip followed by shrubs, then a mix of trees,

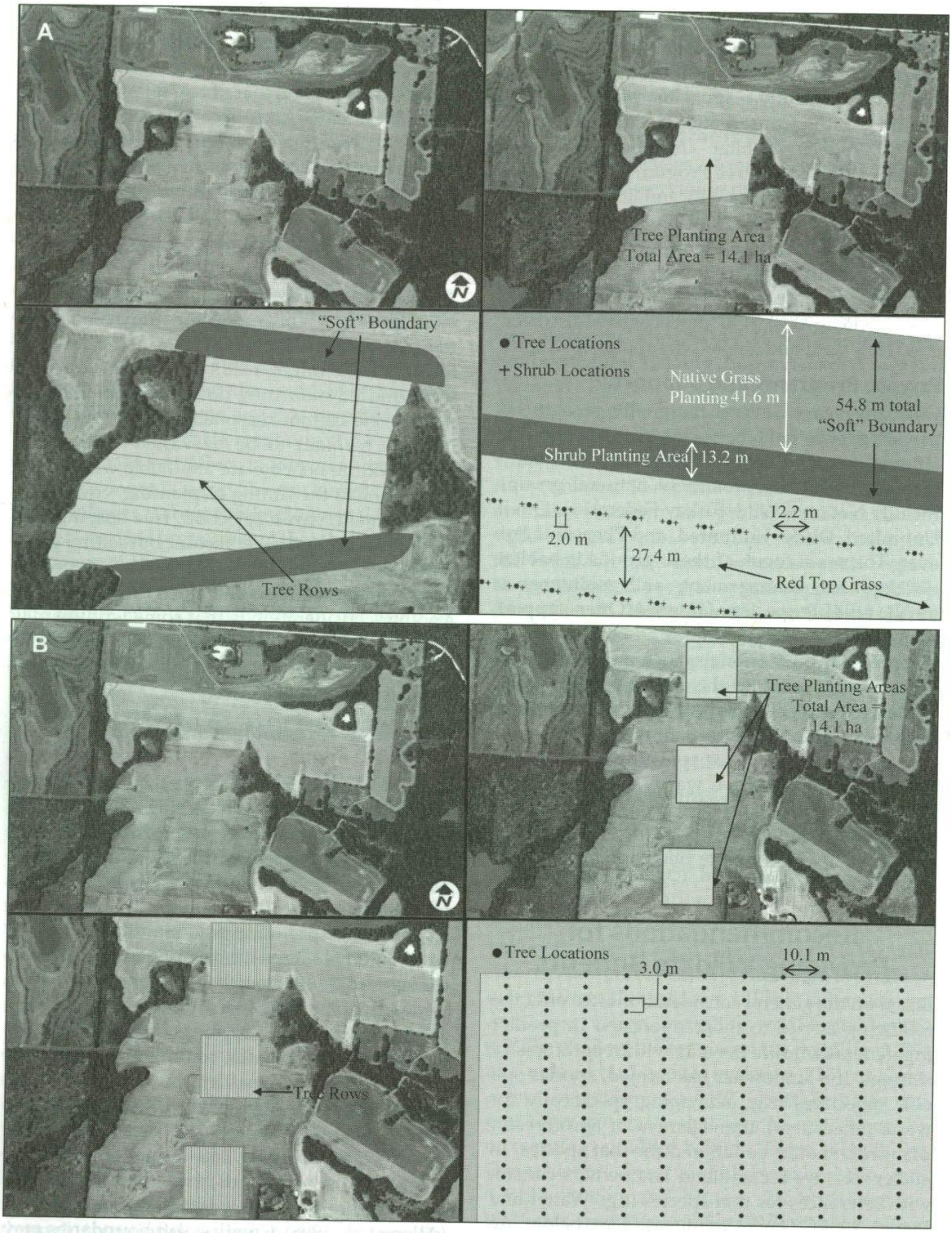


**Fig. 10–5. Contrasting types of agroforestry plantings for the benefit of wildlife. (A) Representation of a wildlife friendly agroforestry planting on the landscape because of the following attributes: (i) an appropriate landscape context that connects previously fragmented environments, (ii) inclusion of a "soft" boundary between the tree planting area and the existing agricultural sites, and (iii) wide spacing between trees and tree rows, inclusion of shrub plantings on either side of each tree, offset tree rows to increase visual obstruction of predators, redtop grass planted within the tree planting area to limit rabbit herbivory, and wide soft boundary that includes a shrub planting area and native grass planting. (B) Representation of a poor example of wildlife friendly agroforestry plantings because of the following attributes: (i) poor site configuration that creates islands of fragmented agroforestry plots, (ii) hard boundaries with no transition among habitat types, (iii) tight spacing between trees and tree rows, which may lead to little or no ground cover and no visual obstruction.**

shrubs, and ground cover. The native grass strip would provide additional habitat while creating a buffer zone between other habitats and the tree plantings. The incorporation of a shrub component (both within the tree stand and alone) again adds diversity, which provides more habitat. Appropriate shrub selection would also provide food resources for wildlife.

Since agroforestry represents a suite of practices that are planned and designed by the landowner, there is an opportunity to create habitat edges that are more transitional, rather than abrupt. By intentionally combining shrubs and taller warm season grasses to outer edges of practices that have traditionally focused on tree species alone, these practices can become structurally diverse components on agricultural landscapes. For example, in an alley cropping configuration, eastern black walnut may be planted to grow a future high-value walnut log. However, when open grown, black walnut tends to retain its lower branches, resulting in boles that must be pruned to maximize their value potential. A different approach might be to plant shrubs on either side of the black walnut. These shrubs could include species such as wild plum (*Prunus americana* Marsh.), roughleaf dogwood (*Cornus drummondii* C.A. Mey.). or false indigo (*Amorpha* L.). At the same time a higher value walnut log is being produced, these shrubs would serve to both shade the bole to encourage natural pruning and provide a softer edge, or transitional zone, which may increase the diversity of birds using the area. Management could be further enhanced by planting a desirable grass along the outer edge. Such a design is similar to the windbreak practice, but more frequently distributed across a given field. Thus, we believe that structural complexity and dimension can be built on agricultural landscapes through the intentional integration of specific agroforestry practices. Design, however, will be specific to the wildlife species of interest.

### 3. Consider landscape context.

The studies we cite above offer strong evidence for the importance of landscape context and issues of edge and fragmentation (Fig. 10–5). When considering location of an agroforestry site, those sites adjacent to agriculture can be expected to promote generalist species (e.g., deer, cottontail rabbits) and will likely not promote area-sensitive species, like forest neotropical migrant birds, or habitat specialists, like swamp rabbits. Expected small game wildlife hunting opportunities (e.g., more quail) might be diminished if the agroforestry site lacks the proper landscape context. The consequences of edge to wildlife should also be considered early in the planning stages. Species such as white-tailed deer will benefit from edge, while forest-dwelling neotropical migrant birds may not. One way to reduce edge effects is by maintaining low edge/area ratios within agroforestry sites. For example, irregularly shaped plots have higher edge than square or circular habitats. Maintaining fewer large areas that are well connected to other similar sites would typically be more beneficial to wildlife than smaller and more scattered sites. Predator traps are possibilities where habitats are isolated, fragmented, and contain a high edge/interior ratio. In fragmented landscapes, landowners should view agroforestry as an opportunity to connect fragmented habitats.

### 4. Know the limiting factors in the environment.

When attempting to improve wildlife benefits, often the greatest impact will be made by meeting needs that current land management practices are not addressing. One way to assess habitat is to gauge what element is most limiting to a given land area becoming more useable for a specific wildlife species. For example, if lack of hard mast is a limiting factor, a landowner might consider planting oak trees to benefit deer and turkey. This recommendation inherently implies the landowner must establish goals. Consideration of area-specific limiting factors not only influences site location and arrangement, but will also drive the selection of plants, shrubs, and cover crops conducive to the site.

### 5. Take care in preparing the site and selecting tree species.

When properly selected, integrated and managed, trees and shrubs can provide opportunities for attracting wildlife at the same time they are developing their own potential products, such as wood value (i.e., timber grown for lumber). Across the United States there are a variety of forest types including Oak–Hickory, Beech–Maple, and Elm–Ash. These forest types are associations, groupings, or complexes of trees that are typically found on similar sites. The distribution of these forest cover types is driven by climate, and predominantly moisture availability, as well as landform and soil. Three areas that we can manipulate and use to influence overall development and productivity are selection of the plant species, location of the plant (landform), and matching a given plant species to specific soils types. First, the selection of plant materials should reflect its potential to enhance land use by a desired wildlife species. Secondarily, this list of desirable plant materials must be suitable for the site to be planted.

Arguably, the most important of site characteristics in determining suitable plant materials (trees, shrubs, and grasses) is the soil, assuming that drastic measures have not altered the state of the soil. By evaluating soil types, proper selection of plant materials can be made that best ensure survival and success of wildlife plantings. Soil type can impart such useful information as flooding frequency and limitations to rooting, as may exist in areas with high levels of clay in a profile. Every state in the United States has soil maps available through the USDA-NRCS (http://soildatamart.nrcs.usda.gov/). The soil types, and their associated properties, will help clarify plant materials to be established or managed for on a given land. Additionally, slope and aspect are important factors; these factors must be considered in tree and shrub selection.

In addition to planting appropriate materials on the right sites, weed control and managing animal damage are important considerations. Weeds are any vegetative material that competes for water and nutrients with a desired shrub or tree. In many parts of the U.S. Midwest, competition comes from grasses. Controlling competing vegetation via herbicide or mulch will improve the chance of tree survival. This should be continued for 3 to 5 yr following planting. Usually, after this length of time, the tree or shrub is well established. Different cover crops might reduce weed competition (e.g., redtop grass; Dugger et al., 2003) and reduce wildlife herbivory of the sites.

Landowner's should also be creative in their approach to tree, shrub, and cover crop selection. For example, many shrubs such as wild plum, blackberry (*Rubus* L.), and wild indigo offer good wildlife food and cover, and do not compete significantly with adjacent plantings (Walter and Pierce, 2007). Planting shrubs next to bare-root tree stock will also stimulate growth of the tree due to the competition. Thus, improvements may be made to tree growth while promoting wildlife benefits of the area.

### 6. Location, location, location.

Dissimilarity in adjacent habitat types limits opportunities for wildlife to traverse the areas (Allen et al., 1996). Boundaries of different land uses differ in their permeability to wildlife. Thus, it is advisable to consider transitions among habitat types and to the agroforestry site. Such habitat barriers can create problems for wildlife movement to and from the site. Providing transitions and similarity in habitat types will enhance wildlife use of the area.

Interspersion of agroforestry plots within older, more established and connected forests has the potential to improve wildlife benefits (Fig. 10–5). During establishment while trees are young, trees provide early successional habitat and a higher quality and quantity of herbaceous material that may be suitable for a diversity of wildlife. As the stand matures, a different wildlife component will become evident. However, these benefits are predicated on the necessary landscape context and general similarity in terms of habitat types and not necessarily age of development.

### 7. Consider the impact of grasslands.

Agroforestry sites within grasslands will often not create widespread wildlife benefits. Despite the utility of shelterbelts and tree cover to some wildlife species in grasslands (e.g., white-tailed deer), some wildlife benefits (e.g., increased nongame birds) may not be attained when developing agroforestry fields in unconnected, open grasslands. In addition to increasing predator densities in these sites (Winter et al., 2000), the isolated nature of these areas may either limit overall wildlife use or result in a predator trap.

### 8. Control for wildlife damage.

In areas with healthy rabbit populations, steps should be taken to reduce damage. Tree guards (Fig. 10–2) offer one practical and economical solution to controlling rabbit damage. Use of an appropriate cover crop, such as redtop grass (Dugger et al., 2003) is another option to reduce rabbit damage because it limits rabbit use of the fields. General control of naturally thick vegetation in the agroforestry field should help reduce rabbit damage. However, rabbits will use surprisingly small patches of cover, so habitat control is difficult. Some repellents are efficient, but many require repeated application, and cost can be high. As trees mature, different species of wildlife may cause damage. For example, deer will begin rubbing their antlers on small trees (Fig. 10–2) causing considerable damage. Fencing is one option to reduce deer damage.

### 9. Explore Lease Hunting Opportunities.

Lease hunting is a viable option for landowners with agroforestry areas. Our mourning dove example represents an excellent lease hunting opportunity for landowners early in the development of the agroforestry plot. Given the potential loss of income during the development of agroforestry plots, a landowner can quickly generate funds through lease hunting, provided they expend the effort to properly manage sunflowers. Through time, hunting opportunities will change (Fig. 10–1). Greentree reservoirs represent another economically feasible option for leasing waterfowl hunting privileges, provided that trees are not damaged during the course of annual flooding.

Careful planning is necessary to manage a lease hunting opportunity. We discussed numerous options for lease hunting and several important factors such as costs, liability, and cover crop management must be considered. As with any other business venture, it takes time and effort for a landowner's investment to be realized. Developing a loyal clientele will further spread news about a landowner's operation, helping further promote the business. Additionally, there are no guarantees with wildlife habitat management because by default the landowner is dealing with an unpredictable wild animal species. A landowner could do everything correct in terms of habitat management and still not attract wildlife. It is expected all landowners will have good years and less successful seasons. We encourage landowners interested in pursuing lease hunting opportunities to speak with other landowners and state biologists to help determine demand, costs they incur, tips on planting, and other issues that are site-specific.

**10. More research is needed to understand the relationship between agroforestry and wildlife benefits.**

There are remarkably few studies that investigate wildlife response to many of the common agroforestry practices. Consequently, we used review materials and recommendations from other, related habitat restoration techniques. However, agroforestry environments are different from traditional agriculture and forest environments and unique enough that further work is warranted. For example, unlike traditional tree plantations, tree spacing is wider and can be staggered for wildlife benefits. Also, more sunlight reaches the ground level, which changes the understory dynamics. There is also a great diversity in planting opportunities in agroforestry areas when compared with either natural forests or traditional tree plantations. All of these unique aspects of agroforestry point to the need to better understand wildlife dynamics in these environments. Although we may draw general principles from the ecological and wildlife management literature, technique-specific information is warranted. We encourage researchers to partner with landowners to obtain information about wildlife benefits from agroforestry situations. For example, data from lease hunting ventures would add some replication to better understand the integration of agroforestry and lease hunting.

## Appendix—Sunflower Field Management in the Midwest

In order for sunflower fields to successfully attract mourning doves for a combined agroforestry and lease hunting operation, lure crops must be ripened by 15 August in Missouri and should be free of weeds, especially grasses. Therefore, planting dates, use of herbicides, and cultivation are all important factors in determining the success of these fields. The following suggestions for planting sunflower fields are based on a decade of field experience from a public hunting area near Kansas City, MO.

**Field Size.** Fields of 4 ha or more will generally produce excellent dove hunting, smaller fields (even 1 ha) sometimes produce good dove hunting. Multiple 4-ha fields interspersed with agroforestry tree plantings have a greater chance of attracting more birds, more hunters, and higher revenue.

**Seed.** Medium (Size #3) seed is preferred. Peredovik sunflower seed (90–100 d maturity) is suggested and can be purchased from local seed dealers or regional specialty seed dealers. Seed costs are low; i.e., $20.00 per 350,000 seeds. Most seed dealers carry Peredovik seed, and some short-season varieties, but the earlier maturing varieties are normally more expensive. Before purchasing seed check with your local county extension agent, local state agency wildlife biologist, or a local nongovernmental organization habitat biologist; they might have some seed available or have local sources at reduced costs for wildlife plantings.

**Herbicide.** Treflan (trifluralin, 2.33 l/ha [1 quart/acre]) or Trifluralin and Eptam (EPTC) (2.33 L ha$^{-1}$ [1 quart acre$^{-1}$]) is recommended as a pre-emergent weed control. Other pre-emergent chemicals are available, such as Prowl (pendimethalin). Ask your local farm supply dealer about appropriate herbicides for the area and follow manufactures rates and safety procedures. Poast-plus (sethoxydim, 2.33 1 ha$^{-1}$ [1 quart acre$^{-1}$]) can be used when sunflowers are too tall to be cultivated and grass has become a problem; grass should be <15 cm for the most effective results. A second application might be needed depending on initial results.

**Field Preparation.** Sunflower fields should be disked once before herbicide application and twice following herbicide application. It is best to disk immediately following herbicide application and then again a few days later. This allows the herbicide to actually work twice before planting. If it is not possible to wait a few days between disking, the herbicide will still provide adequate control.

No-till sunflowers have provided mixed success. For example, different burn-down times combined with Spartan (sulfentrazone) pre-emergent herbicide, has provided some inconsistent broadleaf control. No-till fields, however, tend to have more broadleaf competition because there is nothing to spray over sunflowers to kill broadleaf weeds.

The primary concept to remember about cultivation and weed control is to have nearly bare ground covered with sunflower seed. This will allow the doves the opportunity to locate the seed with minimal effort because of their weak legs, allow the birds to see in all directions to avoid predators, and quickly consume a large quantity of high-energy food before flying off to a nearby roost site.

**Fertilizer.** Use 225 kg $ha^{-1}$ of 13–13–13, or equivalent.

**Planting Dates.** Plant as soon as possible in spring; usually corn planting time is about right. Plant Peredovik type seed *no later* than May 15 (15–25 April is optimal, but there is still a threat of a late frost at this time in many parts of Missouri). Plant short-season seeds (85 d) *no later* than June 1 for best results. The reason behind the early planting is to ensure that the sunflower plants start maturing in late July or early August to begin concentrating and holding doves in the area.

**Planting Rates.** Plant in rows, 0.6 to 1 kg (16,000–22,000 seeds) $ha^{-1}$, depending on seed size. Good results can be obtained using a corn planter with medium flat plates or some equivalent on older model planters. Finger-pick up and vacuum planters will do a better job of calibrating the seed. One seed every 18 to 35 cm $row^{-1}$ is suggested. Rows should be spaced at 75 to 90 cm to allow for cultivation later. Rows spaced at 75 cm and seeds spaced every 18 to 25 cm will develop canopy quicker and reduce weed competition. Planting depth should be approximately 2.5 cm.

**Cultivation.** Cultivate growing sunflowers twice to keep rows free of weeds. Rotary hoeing the sunflowers (if needed) when weeds first begin growing works best. The second cultivation should occur before plants reach 30 cm tall. At ≥30 cm, root damage could result from cultivation. If it is possible to cultivate more than twice, by all means do so since bare ground covered with seed provides the best dove hunting.

**Mowing.** Begin mowing sunflowers in late July or early August. Mow a few rows of sunflowers each week and increase the amount as the season gets closer. Sickle-bar mowing works well with sunflowers by knocking the stalks down, letting them dry a few days, and then brush hogging the sunflowers to shatter the seed heads and scatter the seed. If weeds become a problem in mown sunflowers, light disc this area to create bare ground (repeat as necessary if seasonal precipitation increases weed growth). If you do not have a sickle mower, brush hogging will work well also. Another alternative is the use of brush hogging the sunflower stalks and then use a flail mower to scatter the seed. A flail mower does a better job of pulverizing the stalk and vegetative seed head material, leaving more bare ground and exposed seed.

Sunflowers do not have to be dead or completely brown before mowing. Check several sunflower heads in each field to determine if they have some black seed around the outer edges of the seed head; mowing can begin if there is some seed present. In most years, mowing sunflowers can begin when the heads are still yellow with only firm seed around the outer edges of the seed head. After drying and brush hogging, these early cut sunflowers provide a good amount of seed available for early arriving doves.

Leave field borders with six or eight rows and a larger patch of unmowed sunflowers in the center of the field for winter use for quail, turkey, and song birds. This also provides cover for hunters, depending on the size and shape of the field.

While mowing, keep in mind that the remaining sunflower stalks in the field are where the hunters will hunt during the season, using the standing sunflowers for concealment. Plan ahead and leave cover strips that will provide the best safety possible for hunters in each field.

## Additional Experiences and Notes

- Broadcasting sunflowers has shown some promising success. Prepare the ground like conventional planting, broadcast the seed, and harrow in the seed. Once established, rows can be cultivated into the planting.
- No-till planting of sunflowers has also shown some success, but more experience is needed to deal with the weeds.
- Local conditions (e.g., soil type, precipitation, growing season) can have great effect on successfully growing sunflowers and attracting doves. Try to find landowners or state public

land biologists in your area who would be willing to share knowledge from their experiences.

- Wheat stubble and white proso millet will also concentrate doves if burned and/or disked. These crops take much less care and money to establish, but are not as effective as sunflowers for attracting and concentrating doves, and thus they provide a much less predictable hunting season.
- Canola seed (more popular in northern states) shows some promise as an alternate lure crop for dove hunting. Canola can be planted in the fall like wheat and can provide a food source yearly in the spring to local nesting doves.
- Managing sunflowers to attract mourning doves is difficult work—don't get discouraged if immediate results are not observed the first year. Depending on local farming conditions and local dove populations, it may take several years for local doves to find your field(s) and develop a tradition of using it. To speed-up the process of building a local population of doves accustomed to the area, some "high management intensity" landowners provide bait/feed during winter and spring to attract and build a local population, but be sure to check local state and federal baiting regulations.
- Field size and location will have a large impact on dove use. Smaller fields will generally attract fewer doves than larger fields ($\geq$4 ha). Highly visible fields near good roost trees and water (with a gradual sloping water edge) will attract more doves.

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